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POLAR MAGNETIC DISTURBANCES AND INTRUSION OF
CHARGED PARTICLES INTO THE IONOSPHERE

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SUMMARY

The regularities of appearance of DP are further corroborated by a vast observation material assembled during the IGY. Space-time distribution of 77 bay-like disturbances is evaluated from data of 15 observatories. The equivalent current system is represented at ionosphere heights. The appearance of positive and negative DP and the positions of western and eatsern electrojets are discussed. The entire pattern is discussed in the light of satellite observation data.

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Polar magnetic disturbances (DP) constitute a characteristic singularity of magnetic field variations at high latitudes. Their appearance and intensity are conditioned by two factors: formation of regions of increased ionization as a result of intrusion into the ionosphere of fluxes of charged particles (electrons and protons) and generation of electric fields of ionospheric as well as magnetospheric origin [1--5].

According to observations from AES it was shown in [6] that the relationship between the intensity of a magnetic disturbance on the Earth's surface and the flux of charged particles depends essentially on local time. In connection with this it is of interest to ascertain the space-time distribution of the frequency of appearance and intensity of DP, which is essential for the understanding of the nature of physical processes responsible for the occurrence and development of DP and the variations in the ionosphere and the magnetosphere at time of magnetic disturbances.

The fundamental statistical regularities of appearance of polar disturbances are expounded in [7--10]. Observations in the period of the IGY have permitted to make more precise the well known regularities by means of a vast and uniform material.

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* POLYARNYYE MAGNITNYYE VOZMUSHCHENIYA I VTORZHENIYE ENERGICHNYKH CHASTITS V IONOSFERU

Space-time distribution of 77 bay-like disturbances was considered on the basis of data of 15 magnetic observatories of the northern hemisphere at geomagnetic latitudes $\Phi > 60°$ for the winter season of the IGY. Plotted in Fig.1 is the frequency of appearance of positive and negative DP with amplitude greater than 150 γ. The three-hour interval containing the chosen bay, was characterized by a planetary index $3 < K_p < 5$. The number of bays is about uniformly distributed by two-hour intervals of the day.
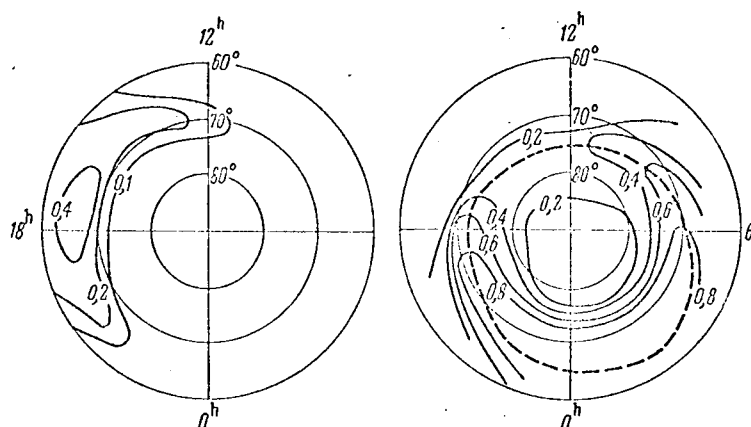

Fig.1 Isolines of the frequency of appearance
of positive (a) and negative (b) DP with ampli-
tude greater than 150 γ

The dashed line is situated at the latitude of
the most frequent appearance of negative DP for
the corresponding local time. The coordinates are
the corrected geomagnetic latitude and local geo-
magnetic time [13 14]

Since the intensity of disturbances varies with U.T., the frequency of appearance of bays at stations with about identical latitudes were averaged so as to diminish this effect. The frequency of appearance of bay-like disturbances was computed as the ratio of the number of bays with $|\Delta H| > 150 \gamma$ to their general number in the corresponding period of local time. When drawing the isolines in Fig.1, interpolation between neighboring values was performed.

Positive DP appear only in in the evening sector during wintertime, on $\Phi < 70°$, with maximum frequency ~ 0.4 on $\Phi = 65°$ at about 1800 hours L.T. Negative DP are observed on all latitudes and at any time of the day. The frequency of their appearance decreases by more than two times from night to day hours, which is determined by bay intensity decrease in this sector. The region of frequency maximum of negative DP appearance has an oval shape, disposed at higher latitudes in daytime than in nighttime. Positive and negative bays are observed simultaneously in evening hours, but at different latitudes. Negative bays are observed closer to the pole. This important case is stressed in [11, 12]. Negative bays with $|\Delta H| < 150 \gamma$ on $\Phi \sim 65°$ appear more frequently than the positive bays by about two times, which is also conditioned by a significantly greater intensity of negative bays.

Shown in Fig.2 is the equivalent current system at ionosphere heights, giving a generalized representation on the magnitude and direction of the perturbed vector in the horizontal plane. Taken into account was also the sign of the perturbed vector in the vertical plane. The equivalent current system consists of two vortices, night and evening. The night vortex, encompassing nearly the entire polar cap, is most intense in morning hours at $\Phi \sim 68°$, and in evening hours at $\Phi \sim 65°$. The electrojet of westerly direction engulfs practically all the longitudes, but its intensity depends on local time with maximum in night and morning hours and minimum in daytime. On the daytime side, at $\Phi \sim 60$ 70°, the current density is negligibly small as a consequence of absence of intense disturbances at these latitudes. Comparison with satellite data shows, that the western electrojet of Fig.2 is disposed along the outer boundary of the radiation belt with 40 kev electrons [16, 17] in the region where AES "INJUN-3" observed the most intense electron aurorae [18].
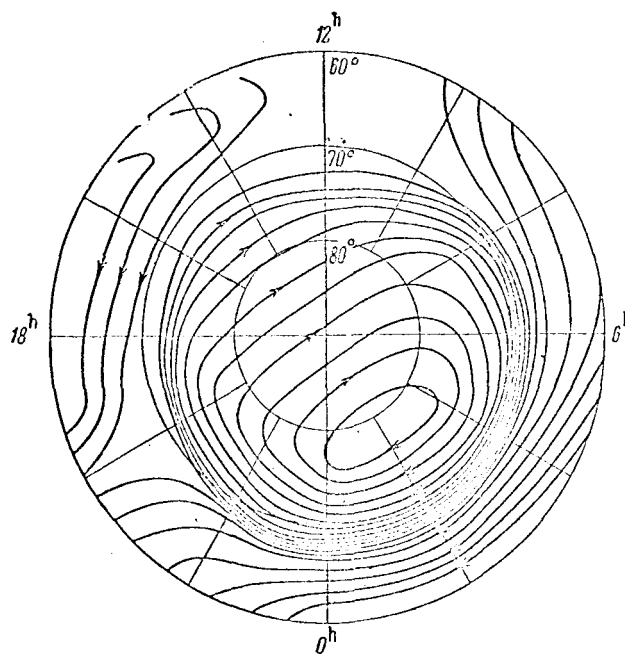

Fig.2   Equivalent current system of DP in winter season
at high latitudes of the northern hemisphere during IGY

The lines are drawn through 20000 a. Account was taken of currents induced in the ground. The coordinates are the corrected geomagnetic latitude and the eccentric dipole time [15]

Therefore the western electrojet is situated in the region of hot plasma runoff from the magnetosphere to ionosphere heights, which determined the appearance in the ionosphere of a whole series of geophysical effects, including the western electrojet. The eccentrical disposition of the western electrojet relative to the pole is conditioned by the asymmetrical shape of the magnetosphere, contracted on the daytime side by the solar wind. The current system of Fig.2 agrees well with the present-day representations on the structure of the geomagnetic field within the bounds of the magnetosphere, and in particular with the formation of the geomagnetic tail.

The eastern electrojet in the evening sector on $\Phi \sim 65°$ is several times less intense than the western one. Since for the computation of the equivalent current system, brought out in Fig.2 we utilized DP at all hours U.T., the small value of the eastern electrojet in evening hours cannot be explained by the absence of observatories registering positive DP, as is done in [19]. It may be assumed that the significantly lower intensity of the eastern electrojet relative to the western is a characteristic peculiarity of the winter season of the IGY [20]. The eastern electrojet closes mainly through middle latitudes. Its separation from the western electrojet presupposes a different nature of positive and negative disturbances [20, 21]. In part cular, it is assumed in [22] that the appearance of the eastern electrojet is conditioned by the electric field, emerging as a consequence of the division of charges intruding into the ionosphere during evening hours.

In the light of latest satellite observations it is impossible to explain the lower intensity of negative DP on the daytime side of the Earth by comparison with the nighttime side by a smaller flux of particles. Satellite data in polar orbit at 340 km altitude have shown [6] that in daytime the energy of intruding electrons with E > 0.08 kev is greater than in nighttime, while the variations of the magnetic field are smaller in daytime than in nighttime. In the course of the experiment the ionosphere was lit at all altitudes during the complete 24 hours at an identical zenithal angle and this is why the effect day--night cannot be explained by the daily variations of physical parameters of the ionosphere. It was noted above to what extent on $\Phi = 60-70°$ the value of magnetic disturbances was small. However, according to Injun-3 the flux of intruding electrons with E > 40 kev in the near-noon hours at these latitudes is more than by one order higher than on the night side [16]. Therefore, satellite observations are evidence that the intr on of intense particle fluxes on the daytime side of the Earth induces there stantially smaller variations of the magnetic field than in night hours. The possible cause of this is the relatively small electric field of magnetospheric origin in daytime.

The equivalent current system represented in Fig.2 may serve as a basis for the computation of electric fields of planetary scale, which exert a substantial influence upon the flow of charged particles in the magnetosphere [23, 24].

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